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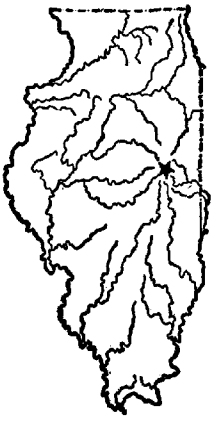
GERM CONTENT OF MILK

I. AS INFLUENCED BY THE FACTORS AT THE BARN

By M. J. PRUCHA and H. M. WEETER



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FOREWORD

The public desire and should be able to obtain a supply of satisfactorily clean and wholesome milk. The representatives of the consuming public in this matter, the health officials, have frequently adopted the germ content of milk as an index of cleanliness and wholesomeness. In this way, the legal limit of germ life permissible in the milk supply as shown by the plate count has been placed in Champaign-Urbana at 100,000 per cubic centimeter and in St. Louis at 5,000,000 per cubic centimeter.

No matter what is our personal judgment regarding the wisdom of such bacterial standards, the legally constituted authorities having thus established these limits of bacterial content, the burden rests upon the producer and the retailer to observe them. When adjusting their business methods to such variable limits as those mentioned above, it is important that the dairymen have fairly accurate knowledge of the relative importance of the various dairy operations upon the germ content of the milk.

In the general directions which the health officials have formulated for the guidance of the dairymen, great stress has been laid upon the construction and condition of the cow stable. Accordingly, technical studies of the influence of dairy factors naturally included a measurement of the influence of barn conditions. The results obtained at the New York Agricultural Experiment Station from such technical studies of the influence of barn conditions were so out of keeping with the ideas of the health officials that it seemed best to redetermine independently this relationship at this experiment station.

The surprisingly accordant results which have been obtained at these two experiment stations should not be understood as countenancing dirty methods or dirty milk. They merely point out that earlier impressions, formed in the absence of exact data, did not give a correct value to the importance of barn conditions in connection with germs in milk.

Neither should these results be taken as a criticism of health officials. Such officers are charged with the protection of the public health. Where the facts are available, they utilize them. Where exact information is lacking, they must proceed in accordance with their best judgment even tho they recognize the fallibility of such judgment.

The slight effect of barn conditions upon the number of germs in milk was clearly brought out by the extended studies at the New

York Agricultural Experiment Station. The studies here reported were made in a different part of the country, in three quite dissimilar barns, by a different laboratory force, using a different method of attacking the problem. The results of this latter study are quite in accord with those obtained in New York.

The earlier misconceptions of health officials regarding the importance of barn conditions resulted in placing unjust economic burdens upon the producer. Now that more accurate data upon this question is available it is to be hoped that these burdens will be more fairly distributed.

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GERM CONTENT OF MILK

I. AS INFLUENCED BY THE FACTORS AT THE BARN

By M. J. PRUCHA, ASSISTANT CHIEF IN DAIRY BACTERIOLOGY, and
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INTRODUCTION

The studies on which this bulletin is based are à part of an investigation begun by H. A. Harding in 1906 at the New York (Geneva) Agricultural Experiment Station. In an introduction to Bulletin 365 of that institution Dr. Harding makes the following statement as to the purpose of the investigation: "When health officials, failing to find other means of characterizing sanitary milk, undertook to specify the conditions under which it should be produced, they were confronted by an almost total lack of detailed information upon this subject. This lack arose from the fact that available studies upon milk sanitation were in the nature of general surveys of the situation. While these general surveys were a necessary preliminary, they gave little information as to either the absolute or the relative importance of any given dairy operation. . . . . The importance of the interests involved demands that the needed information shall be furnished as promptly as possible."

Investigations toward this end have been carried on at the New York Agricultural Experiment Station since 1906.[1] The aim in these investigations has been to separate the various sources of contamination to which milk is subject and to measure the influence of each on the germ content of milk. The results from these studies point to the conclusion that barn conditions and barn operations have only a small influence upon the germ content of milk.

If the above conclusion is true, it will radically change our conception concerning the relative importance of the different sources of milk contamination. Since it is an axiom in scientific work that no important results are accepted until they have been verified independ-

[1] Harding, H. A., Wilson, J. K., and Smith, G. A. Milking Machine: Effect of Methods of Handling on the Germ Content of Milk. N. Y. (Geneva) Agr. Exp. Sta. Bul. 317. 1909.

Harding, H. A., and Wilson, J. K. The Modern Milk Pail. N. Y. (Geneva) Agr. Exp. Sta. Bul. 326, pp. 248-281. 1910.

Harding, H. A., Ruehle, G. L., Wilson, J. K., and Smith, G. A. The Effect of Certain Dairy Operations upon the Germ Content of Milk. N. Y. (Geneva) Agr. Exp. Sta. Bul. 365, pp. 198-233. 1913.

Harding, H. A., and Wilson, J. K. A Study of the Udder Flora of Cows. N. Y. (Geneva) Agr. Exp. Sta. Tech. Bul. 27. 1913.

Ruehle, G. L. A., and Kulp, W. L. Germ Content of Stable Air and Its Effect upon the Germ Content of Milk. N. Y. (Geneva) Agr. Exp. Sta. Bul. 409, pp. 418-474. 1915.

ently by other workers, it was decided to repeat the study made at the New York Station upon the influence of barn conditions and operations on the germ content of milk. Accordingly, the subject has been restudied at the Illinois Station by a new force of workers, in a new laboratory, and in three barns of distinctly different types. The method of attack in the present study differed from the method used at the New York Station in that all the barn factors were grouped together and their collective influence on the germ content of the milk was determined. In these, as in the previous studies, the utensils were considered as a separate source of contamination and were therefore thoroly steamed before each milking.[1]

THE THREE BARNS IN WHICH THE STUDY WAS MADE AND THE DAIRY METHODS EMPLOYED IN EACH

In order that the results of this study may be thoroly understood and their significance fully appreciated, it is necessary to give a somewhat full description of the conditions and the dairy operations in each of the three barns in which the experiment was conducted.

Barn I is a two-story frame building 75 feet long and 45 feet wide. There are approximately 900 cubic feet of space and 9 square feet of window glass per cow. Two rows of iron stalls facing the central aisle and running lengthwise accommodate forty cows. The length of the floor from the manger to the gutter is 5 feet 5 inches in one row of stalls and 5 feet in the other row. The iron stalls used in this barn are known as "Drown" stalls, and are so constructed that it is possible, to a certain extent, to adjust the space inside the stall to the size of the animal.

The ceiling and the walls are constructed of matched lumber, are painted, and are without any large crevices. The floor, the gutters, and the mangers are of cement. The feeding materials are stored in a separate part of the building and are brought into the barn thru an end door.

During the investigation, the milkings began at five in the morning and at four in the afternoon and lasted an hour and a half. After the morning milking, the cows were turned out into a yard, the manure was taken out, the floors were flushed with water, and the stalls were bedded with sawdust. When feasible, the manure was placed directly on the wagon and taken away. At other times it was dumped about thirty-five feet from the barn in a yard to which the cows did not have access. A tight board fence, six feet high, separated this manure pile from the barn.

After the barn had been cleaned, the cows were brought back, fed hay, and cleaned. The amount of time spent on the cleaning of the

[1]The influence of dairy utensils upon the germ content of milk has been studied separately and the results will be reported later.

cows was approximately five minutes to each animal. Occasionally the cows were used for demonstration purposes before classes, and for such occasions their udders and flanks were clipped. This clipping, however, was not practiced regularly for the purpose of reducing the number of bacteria in the milk. Likewise, during the experiment, no systematic attempt was made to clean the cows before each milking. If any of them became dirty prior to the milking, the milker wiped the loose dirt from their flanks and udders with a handful of the sawdust bedding. In 1914 the udders of the cows were wiped with a damp cloth previous to the milkings, but in 1915 this practice was discontinued intentionally.

During the milking the cows were fed silage and grain. The hay was brought into the barn usually before the milking was finished, and was distributed into the mangers. This operation frequently caused a considerable amount of dust in the air. The milkers wore milking suits which were changed twice each week.

Barn II is a two-story, circular building 70 feet in diameter. There are about 800 cubic feet of space and 9 square feet of window glass per animal. The platform upon which the cows are stanchioned is circular, running around a central ring 45 feet in diameter. Around the outer edge of this platform is the gutter, and between the gutter and the outside brick wall runs a passageway about six feet in width.

Especial effort was made in constructing this barn to so equip it that the cows would be prevented from lying down in their own feces.

FIG. 1.—THE INTERIOR OF DAIRY BARN I

This was accomplished by varying the width of the platform upon which the cows are stanchioned and by installing adjustable stanchions. By these two means the space for each cow can be adjusted as desired.

The brick wall and the wooden ceiling are free from any large crevices, but are rough and not painted. The platform upon which the cows are stanchioned is paved half way around with cork bricks and the other half with creosote blocks. In the center of the barn is a silo 16 feet in diameter and the chutes for the grain and the hay which are stored on the second floor.

With few exceptions the daily operations in this barn were about the same as in Barn I. The floor was cleaned regularly, but as a rule was not flushed with water. In cleaning the cows, only about one minute of labor a day was allowed for each animal, while in Barn I a period of five minutes was devoted to that purpose. This reduction in labor in keeping the cows clean was brought about by carefully adjusting to their size the spaces in which the cows were stanchioned. During milking and feeding and in unfavorable weather the cows were stanchioned in the barn; at other times they were turned out into an acre dry-lot adjacent to the barn.

Barn III is a two-story, round, basement barn 50 feet in diameter. Only ten cows occupied it during this experiment, each animal having approximately 1,500 cubic feet of space and 15 square feet of window glass. In the center of the barn are the silo and the grain and the hay chutes. Around these is a circular passageway 10 feet in width. On the outer edge of this passageway are the mangers and the stanchions, both constructed of wood. There is only a dirt floor and there are no gutters. The brick side-walls and the wooden ceiling are tight but are not painted. During the experiment the cobwebs and the dust were abundant, not having been cleaned from the ceiling for four years previous.

The cows were stanchioned only during the milkings. Between milkings they were allowed to roam about in the barn and in the quarter-acre dry-lot adjacent to the barn. A large door leading from the barn into the dry-lot was always open. The floor in the barn was covered with straw once a day, but the manure was allowed to accumulate on the floor and was removed from the barn only twice a year. The cows were not kept as clean as in Barns I and II, but no manure was allowed to accumulate and to cake on their flanks and udders.

These three barns in a general way represent three classes of dairy barns, Barn I being in excellent condition, Barn II being good, and Barn III poor. The difference between Barn I and Barn II as to cleanliness, however, was not very great. On the other hand, Barn III would be classed as a dirty barn, and it is doubtful whether the milk from it would be admitted to the market of some cities. A photograph of each of the three barns is shown in Figs. 1, 2, and 3.

FIG. 2.—THE INTERIOR OF DAIRY BARN II

FIG. 3.—THE INTERIOR OF DAIRY BARN III

METHODS OF STUDY

Sterilization.—The media used in determining the germ content of the samples of milk were sterilized in test tubes in the autoclave for fifteen minutes at 120° C. In order that all the test tubes might receive the same amount of heat, they were held during the process of sterilization in test-tube racks.

All the glassware and other laboratory apparatus withstanding dry heat were sterilized by subjecting them to 160° C. in a dry sterilizer for two hours or more.

The pails used for milking in Barn I were steamed for three minutes over a jet. In Barns II and III the pails were steamed in a sterilizer, which was a box constructed of galvanized iron. After such steaming, the pails were always examined for the presence of living bacteria which might have survived the steaming. This examination consisted of rinsing out each pail with 500 cc. of sterile water just previous to milking and then determining the number of bacteria in the rinse water.

The examination indicated that all the pails steamed in the sterilizer and 112 of the 130 pails steamed over the jet were free from bacteria. The remaining 18 pails steamed over the jet were not entirely sterile, but the number of bacteria found in them was extremely small and did not affect measurably the results of this study.

Taking of Samples.—All the samples were taken from the milk of the individual cows when the milker brought it in pails from the barn into the adjacent milk room. The milk was thus exposed to all the sources of contamination in the barn. After a thoro stirring with a sterile iron spoon fifteen inches long, the desired amount of milk was transferred by means of the spoon into a large test tube. The milk samples were immediately cooled to about 54° C., and were plated, as a rule, within one hour.

Dilutions and Plating.—Wide-mouthed, glass-stoppered bottles of 250-cc. capacity were used as dilution bottles. This type of bottle was used at the suggestion of Professor W. A. Stocking, Jr., of Cornell University, and was found to be an improvement on the ordinary dilution bottle with a cotton plug. The bottles were sterilized in the dry oven, and just before plating, the required amount of sterile water was introduced into each by means of a graduated pipette.

Two dilutions, 1 to 10 and 1 to 100, were made from each sample. For the first dilution 5 cc. of milk was added to 45 cc. of water, and for the second dilution, 1 cc. of milk was added to 99 cc. of water. Every bottle was then shaken violently, receiving 30 double shakes in such a manner that with each single stroke the bottle passed thru a distance of ten inches. From each dilution two plates were seeded, each one with 1 cc. of the bacterial suspension.

It is well known that in the quantitative bacteriological examination of milk by the plate method, plates seeded with the same milk will rarely develop the same number of colonies, even when the plating is done with care and accuracy. In order to ascertain the extent of variation due to the laboratory methods employed in this study, ten experiments were undertaken in each of which 100 plates were seeded with the same milk. The same dilution was used for all the plates in each experiment. The results from one of these experiments are shown in Table 1.

TABLE 1.—FREQUENCY DISTRIBUTION FOR NINETY-SIX PLATES[1] MADE FROM THE SAME BACTERIAL SUSPENSION

Class	Number of colonies per plate	Frequency distribution
1	110–120	111
2	121–130	𝍸 𝍸 1
3	131–140	𝍸 𝍸 𝍸 𝍸 𝍸 111
4	141–150	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 1111
5	151–160	𝍸 𝍸 1111
6	161–170	𝍸 1

[1]Four of the 100 plates were spoiled.

The mean number of colonies for all the plates in this experiment was 142, while the lowest count was 110 and the highest count was 170. In order to show the frequency distribution of the plates, they were divided into six classes, each of which had a class range of ten units. It will be seen from Table 1 that of the 96 plates counted, 62 fell into the third and fourth classes, having more than 130 and less than 151 colonies. With respect to variability, it is important to note that these individual counts showed very moderate variation. Indeed, no individual count deviated as much as 25 percent from the average. The other nine experiments on this subject showed approximately the same variation. According to the theory of statistics, the average of the counts for sets of four plates would tend to be about half as variable as the counts of the individual plates. Since, with but few exceptions, every determination in Tables 2 to 7 was an average of four plates it seems reasonable to conclude that the wide variations in the germ content of the samples shown in these tables were due primarily to variations in the number of bacteria actually present in the samples of milk and not to inaccuracies of the laboratory methods.

Medium.—The following medium was used thruout the entire study.

Agar shreds	15 grams
Liebig's meat extract	3 "
Witte's dry peptone	10 "
Lactose	10 "
Distilled water	1000 cc.

The reaction of the medium was adjusted to 1.0 percent normal acid to phenolphthalein.

Incubation and Counting.—All the plates were incubated for five days at 20° C., and for two days at 37° C. This length of time and the two temperatures of incubation were used in order to induce a larger number of the bacteria present in the milk to form visible colonies. According to Harding and Wilson,[1] the bacteria that form colonies at 37° C. but not at 20° C. may occasionally be present in the freshly drawn milk.

As stated above, two dilutions were made from each sample of milk and two plates were seeded from each dilution. All four plates from each sample were counted regardless of the number of bacteria on them, unless they showed some evidence of contamination. In Tables 2 to 7, therefore, the number of bacteria given for each sample of milk is an average based upon four plates.

RESULTS OF THE STUDY

As stated before, the samples were taken from the milk of individual cows. In Barn I, 511 samples were taken from 35 cows in 1914, and 349 samples from 37 cows in 1915. In Barn II, 360 samples were taken from 26 cows in 1914, and 207 samples from 21 cows in 1915. Of the 238 samples in Barn III, 161 were taken from 10 cows in 1914, and 77 from 9 cows in 1915. The data from the analyses of these samples are given in Tables 2 to 7.

[1]Harding, H. A., and Wilson, J. K. A Study of the Udder Flora of Cows. N. Y. (Geneva) Agr. Exp. Sta. Tech. Bul. 27. 1913.

TABLE 2.—GERM CONTENT OF THE INDIVIDUAL SAMPLES OF MILK: BARN I, 1914

Cow No.....	26	35	55	63	73	74	110	111	112	130	134	135	150	152	154	155	156
Sample No.	Number of bacteria per cc. of milk																
1	305	5705	32250	3257	377	470	450	5485	6900	1672	252	270	575	375	192	420	612
2	250	565	3332	642	677	1170	1300	3512	3270	2760	710	135	592	897	425	655	770
3	337	112	218250	547	192	200	1290	10800	2522	927	167	197	907	572	842	1002	847
4	495	177	52287	1007	812	233	945	10500	1477	105	680	130	700	1587	900	255	505
5	1597	142	15925	1645	3627	487	497	3095	385	120	1890	170	235	156	1167	62	325
6	840	312	20237	110	1282	542	487	7287	1282	240	907	310	355	300	495	132	315
7	3800	197	10875	220	360	97	540	3122	1400	2255	210	365	322	365	1407	105	483
8	367	730	3850	192	445	272	266	6250	897	742	380	352	545	8060	760	406	477
9	745	557	13040	602	332	1183	335	6235	1815	477	1540	47	280	152	343	77	647
10	292	500	128095	447	300	2095	926	15812	1685	510	2770	205	890	90	2942	885	687
11	326	657	11077	302	1025	4850	245	4022	1247	77	3395	476	1457	450	4157	2560	1220
12	140	82	2960	790	387	1017	495	6467	672	110	2702	352	317	290	2285	2350	2117
13	2912	40	4400	263	1322	605	502	6200	765	107	615	1215	130	1042	840	107	1102
14	527	172	2255	72	2450	657	1032	11327	342	192	792	195	256	290	2557	140	1055
15	150	905	.....	272	317	192	....	4380	5500	4000	457	....	50	....	352	40	281
16	....	....	.....	142	....	....	....	4875	....	....	....	....	....	....	....	....	....
Average	872	723	25131	657	927	931	665	6835	2010	951	1164	325	506	1044	1307	613	763

TABLE 2.—*Concluded*

Cow No....	167	171	172	174	176	177	178	179	180	182	184	186	187	188	189	190	191	192
Sample No.	Number of bacteria per cc. of milk																	
1	985	412	1162	492	1685	1780	1215	135	28950	3425	6275	1502	327	58275	437	6225	1883	2130
2	1563	1480	5815	532	845	1020	487	1487	555	1475	5020	977	260	487	495	1115	1585	2182
3	1522	545	2600	265	553	887	1312	732	420	560	2987	1637	480	320	2502	910	3155	1410
4	1050	455	6355	70	1060	687	1332	1130	416	282	252	347	312	67	115	555	2622	1415
5	47	300	8505	170	720	890	650	2760	350	290	240	845	397	80	162	775	10135	587
6	282	272	7712	45	1162	1783	760	2177	235	330	233	820	663	130	60	705	320	627
7	77	670	2850	82	577	82	855	103	492	367	307	1363	1932	115	840	695	1412	506
8	67	840	2980	72	395	332	935	130	1225	975	1635	657	935	2847	190	1227	5937	1650
9	297	955	2060	155	805	260	567	263	2665	497	356	1327	377	82	92	337	657	737
10	225	490	937	17	332	700	1200	292	132	602	135	735	685	186	50	950	666	262
11	100	527	1370	200	1323	125	1087	1165	247	663	337	666	375	67	222	782	1295	242
12	180	607	3623	173	840	876	1032	436	350	536	250	740	772	126	100	647	442	592
13	66	395	4122	122	697	432	932	565	452	....	440	2400	432	....	112	710	455	265
14	100	315	4045	130	652	....	1100	355	482	....	222	800	247	....	252	927	427	253
15	45	765	....	225	755	....	412	....	972	....	2185	816	....	....	172	540	....	475
16	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Average	444	602	3874	183	826	758	925	837	2529	833	1391	1042	585	5231	387	1140	2213	888

TABLE 3.—GERM CONTENT OF THE INDIVIDUAL SAMPLES OF MILK: BARN I, 1915

Cow No.....	26	55	73	74	110	112	130	134	135	150	152	155	156	167	171	172	174	176
Sample No.	Number of bacteria per cc. of milk																	
1	632	5750	2305	....	1272	1490	9212	1047	692	1962	14862	540	552	1342	1457	....	172	3972
2	350	51025	1007	165	2832	1862	4817	1530	775	1372	2493	307	720	6517	1120	6740	185	1982
3	587	11675	....	297	685	332	5245	737	1350	1430	33812	320	737	4502	1505	6665	2555	1555
4	3140	28725	....	400	590	3215	8340	737	936	542	897	372	1162	7162	4027	6390	355	2557
5	1567	23765	....	940	5290	3402	10980	445	750	852	4585	235	257	7107	930	11032	367	2757
6	657	55700	....	205	1207	4757	5487	397	662	652	2652	267	2065	5885	4430	2977	1140	4455
7	3617	24525	....	282	777	1440	10873	....	962	950	35675	525	1000	3653	1100	3327	2555	2570
8	735	22575	....	117	1460	1310	14070	285	760	622	2763	515	642	6502	2277	2097	180	6085
9	2050	5215	....	4660	1755	877	7465	1130	820	550	32855	432	1686	14312	4550	1937	120	1672
10	1455	39450	....	1807	930	3170	8012	1300	1002	1262	1092	575	802	3940	4192	2792	3545	1182
Average	1479	26840	1656	986	1679	2185	8250	845	870	1019	12168	408	962	6092	2558	4895	1117	2878

TABLE 3.—*Concluded*

Cow No.	177	179	180	181	187	188	189	190	191	192	193	194	195	196	198	199	200	202	203
Sample No.	Number of bacteria per cc. of milk																		
1	20350	112	480	....	1825	....	1087	4457	12737	685	1837	3400	1575	175	1045	3105	840	3600	630
2	2562	332	377	2517	897	150	1855	5530	2237	510	2582	1977	547	725	766	4555	1112	1750	1090
3	4710	332	700	2005	720	267	1087	6207	3607	555	2147	2072	6240	300	1250	5057	797	1665	1030
4	1230	1792	710	2342	802	352	1005	8302	6292	1205	2605	2147	360	403	952	5070	2115	3612	1300
5	5695	402	2012	550	1617	....	1475	....	4452	1095	3977	2090	5897	385	780	7240	4297	4632	1115
6	2182	1450	1100	6592	450	1422	1302	2207	2552	590	3055	8767	1615	586	840	3467	1052	5382	....
7	6383	605	447	3020	1815	732	1067	6830	3166	6097	3432	4007	1387	355	1280	2327	1680	1992	....
8	3130	1940	615	2242	732	2107	1775	5055	4635	2016	5577	1787	502	450	925	2590	830	932	....
9	2167	3100	275	1630	1167	465	2110	2892	2342	785	2907	1230	553	647	1372	1480	....	4385	....
10	1272	820	717	895	1165	250	1640	2615	3697	1225	1435	690	1312	517	917	5105	3097	6560	....
Average	4968	1088	743	2421	1119	718	1440	4899	4571	1476	2955	2816	1998	454	1012	3999	1757	3451	1033

TABLE 4.—GERM CONTENT OF THE INDIVIDUAL SAMPLES OF MILK: BARN II, 1914

Cow No.	108	113	116	117	118	123	125	131	137	145	149	159	164
Sample No.	Number of bacteria per cc. of milk												
1	862	647	422	2397	1462	140	290	500	2587	1075	172	1562	762
2	582	100	90	700	402	75	127	232	1812	380	159	835	475
3	1470	185	125	1225	625	605	90	3230	2150	1222	142	....	985
4	1337	1307	50	1442	1677	157	232	855	1083	243	302	1030	1200
5	1837	707	815	4025	5462	365	1175	2220	1825	1720	610	2530	5075
6	1000	1221	668	793	12955	1078	3473	573	1400	1660	507	1845	514
7	737	232	95	156	96	23	108	1139	460	230	62	56	255
8	327	869	72	324	645	3	140	4001	482	312	273	107	128
9	42	400	107	70	90	157	189	1009	433	218	398	11	32
10	31	284	106	316	11	90	50	946	1264	52	151	239	83
11	450	665	160	1167	145	472	462	2970	1242	1860	715	567	1600
12	764	386	477	1787	722	572	1756	2767	1366	967	600	313	472
13	2247	1132	215	1285	270	930	640	1200	1662	317	920	960	1987
14	317	977	....	1560	280	192	1050	4075	1553	432	480	515	596
15	1550	425	....	1027	537	80	690	2062	1217	160	207	....	225
Average.....	770	636	265	1217	2752	329	698	1878	1369	657	373	813	966

TABLE 4.—*Concluded*

Cow No.	165	166	170	175	183	550	551	552	553	554	555	556	557
Sample No.	Number of bacteria per cc. of milk												
1	462	322	205	1362	906	342	2812	845	697	1050	1175	1745	510
2	45	112	....	3450	517	30	1417	120	1117	995	2692	437	820
3	387	240	27	2465	1950	575	2920	227	1977	797	5325	1730	480
4	130	75	47	....	270	602	815	352	587	837	970	667	....
5	1087	890	582	....	6612	4862	3250	532	757	1700	7505	2150	....
6	323	257	391	....	1459	1590	1782	1214	759	4633	380	4444	....
7	70	154	387	....	458	142	116	64	108	126	29	263	....
8	282	260	98	....	449	86	2000	70	445	257	115	92	....
9	....	116	51	....	225	1414	168	63	1073	107	98	100	....
10	355	53	67	....	487	98	44	357	1472	2689	368	95	....
11	350	167	255	....	1830	137	855	4025	745	1887	637	1090	....
12	647	685	352	....	562	200	1308	424	1067	1527	705	1630	....
13	326	182	457	....	3850	262	302	407	1317	4925	440	450	....
14	147	442	142	....	337	310	320	405	2012	905	385	1567	....
15	382	482	155	....	1287	383	722	447	1540	947	33000	300	....
Average.....	356	295	222	2425	1613	735	1258	635	1045	1292	3588	1117	603

TABLE 5.—GERM CONTENT OF THE INDIVIDUAL SAMPLES OF MILK: BARN II, 1915

Cow No....	116	117	118	123	145	149	159	164	166	170
Sample No.	Number of bacteria per cc. of milk									
1	285	210	1452	3790	390	515	175	705	75	525
2	220	85	1047	145	605	1055	740	857	135	120
3	300	245	1290	275	110	460	150	45	455	335
4	517	180	462	547	3885	....	407	1530	182	307
5	256	...	2113	335	460	1100	166	765	30	115
6	372	267	1802	1665	655	1130	50	2267	60	636
7	256	85	4910	205	480	1010	250	670	77	1305
8	262	342	967	480	836	965	185	900	70	1992
9	142	205	3482	252	640	1185	397	652	175	467
10	475	85	135	317	805	692	592	1090	240	537
Average..	308	189	1766	801	886	901	311	948	149	633

TABLE 5.—*Concluded*

Cow No.....	183	501	550	551	552	556	558	559	560	561	562
Sample No.	Number of bacteria per cc. of milk										
1	735	150	3352	885	190	4020	260	1202	2133	90	165
2	4077	115	2350	300	80	1090	70	1372	25	215	595
3	585	280	1792	740	270	240	362	235	350	255	755
4	435	365	19032	570	242	477	272	255	14385	1587	1905
5	495	197	1347	210	...	2327	85	77	305	135	2107
6	677	195	1380	442	140	340	285	217	587	375	1880
7	1436	417	1845	176	140	690	247	50	20	75	1427
8	602	110	1122	82	382	1370	425	107	20	210	2042
9	745	170	1532	180	225	2980	422	1755	15	2280	1222
10	685	365	2242	380	245	215	235	285	50	265	1780
Average.....	1047	236	3599	396	212	1374	266	555	1789	548	1387

TABLE 6.—GERM CONTENT OF INDIVIDUAL SAMPLES OF MILK: BARN III, 1914

Cow No...	1003	1015	1018	1019	1025	1026	1031	1032	1033	1034
Sample No.	Number of bacteria per cc. of milk									
1	8775	8750	5547	4562	1987	11812	1815	9275	3792	307
2	7725	6705	8125	1925	5675	12325	2166	5625	2980	647
3	17750	8472	2350	2820	22146	19825	1483	6582	4955	1000
4	9875	1453	2120	865	1923	14175	1088	5260	2090	538
5	11650	3525	3675	563	970	16600	1110	3275	855	433
6	25312	3433	5735	7285	2130	13265	1932	6457	1757	652
7	15237	6110	10977	1092	3060	21075	5912	4733	5282	1072
8	8095	12108	3048	1223	2117	16875	2338	3788	3193	645
9	9725	4202	4977	1962	2045	14725	1510	1870	1825	857
10	10338	9380	2905	1620	3255	34525	2343	5673	2695	1198
11	29500	.....	4417	2287	3900	18400	2112	2285	4647	892
12	9700	.....	5210	3820	4860	14087	3215	6692	3915	5875
13	19150	.....	9792	2707	2555	63835	1620	1575	5367	20365
14	5825	.....	2215	5062	4498	9125	2340	4675	3895	3537
15	18950	.....	3505	3300	3552	26135	9690	1390	5925	2330
16	3425	.....	2177	3150	4452	7480	9725	5606	6480	3000
17	12013	.....	13735	2475	.....	10300	.....	3430	18520	1972
Average	13120	6414	5324	2748	4320	19092	3150	4603	4598	2667

TABLE 7.—GERM CONTENT OF INDIVIDUAL SAMPLES OF MILK: BARN III, 1915

Cow No.....	113	137	1015	1018	1019	1031	1032	1033	1034
Sample No.	Number of bacteria per cc. of milk								
1	20800	2347	7270	3197	3787	1252	4355	4515	342
2	13760	2277	4787	7117	1317	....	1745	4922	2787
3	2052	2767	.....	5025	7920	5687	6362	2957	2047
4	1315	2300	.....	9877	3967	8377	8690	3120	6467
5	1065	2230	17705	2890	1877	....	8970	8350	690
6	905	1175	6672	48600	6252	....	9472	4265	1230
7	2350	2257	.....	4235	2395	725	800	3807	2610
8	4885	1325	.....	4067	1752	....	2085	6392	1537
9	18602	887	9456	3777	2107	....	3292	5180	447
10	4185	3680	.....	4635	6225	....	....	....	1555
Average.....	6991	2124	9178	9342	3759	4010	5086	4834	1971

GERM CONTENT OF THE INDIVIDUAL SAMPLES OF MILK

Since the samples for this study were taken from the milk of the individual cows after it was brought in the pails from the barn into the milk room, the number of bacteria present in the milk was due to the collective influence of all the different sources of contamination at the barns. An examination of the foregoing tables shows that nearly every sample of milk had a different number of bacteria. Among the samples from Barn I, the lowest germ content was 17 and the highest was 218,250 bacteria per cubic centimeter of milk; in Barn II the lowest was 3 and the highest was 33,000; and in Barn III the lowest was 307 and the highest was 63,835. These are wide limits of variation in the germ content of milk produced under uniform barn conditions. However, the number of samples with high germ content was very small, especially in Barn II and Barn I; as a matter of fact, most of the samples of milk had an extremely low germ content. This is a conspicuous feature of the data, which is brought out more clearly by arranging the samples into the groups shown in Table 8.

TABLE 8.—GROUPING OF ALL MILK SAMPLES ACCORDING TO GERM CONTENT

	Below 1,000 per cc.	Between 1,000 and 5,000 per cc.	Between 5,000 and 10,000 per cc.	Between 10,000 and 50,000 per cc.	Over 50,000 per cc.
Barn I.....	472	297	56	29	6
Barn II.....	405	153	4	5	0
Barn III.....	19	127	57	34	1
Total....	896	577	117	68	7

Of the 860 samples from Barn I, 472, or 54.9 percent, fall into the first group; 297, or 34.5 percent, fall into the second group; 56, or 6.5 percent, fall into the third group; 29, or 3.4 percent, fall into the fourth group; and 6, or 0.7 percent, fall into the fifth group. In Barn II, 405 samples, or 71.4 percent, fall into the first group; 153, or 27 percent, fall into the second group; 4, or 0.7 percent, into the third group; 5, or 0.9 percent, into the fourth group; and not a single sample is in the fifth group. In Barn III, 19 samples, or 8 percent, are in the first group; 127, or 53.3 percent,in the second group; 57, or 24 percent, in the third group; 34, or 14.2 percent, in the fourth group; and only one sample, or 0.5 percent, in the fifth group.

The influence of the barn conditions upon the germ content of milk from the individual cows is clearly seen in the above grouping of the samples. As judged by the general appearance of the barns and by the amount of labor devoted to the cleaning both of the barns and of the cows, Barn I was cleaner than Barn II, and Barn III was the dirtiest of the three barns. It is seen from the above data that the samples of milk from Barn III had, on the average, decidedly higher

germ content that the samples from Barns I and II, but in view of the difference between the conditions in Barn III and the conditions in the other two barns it seems remarkable that so many samples from Barn III had such a low germ content and that the difference between the results from this barn and those from the other two barns was so small.

The comparison of the results from Barn I with those from Barn II, on the other hand, shows that there was a larger proportion of the samples from Barn II with a low germ content than from Barn I, in spite of the fact that the latter barn was cleaner. This and the fact that most of the samples from both barns had such low germ content clearly indicate that the barn conditions and operations in these two barns contributed but a small number of bacteria to the milk. Why there should have been a larger number of samples with high germ content from Barn I than from Barn II is not certain, but it will be noticed that most of the samples with high germ content in this barn came from certain few animals. The most conspicuous case was Cow 55. This animal persistently gave milk with high germ content and subsequent studies showed that her udder was the source of these larger numbers of bacteria in her milk.

AVERAGE GERM CONTENT OF THE MILK OF THE DIFFERENT ANIMALS

The average germ content of the milk of each animal was calculated from the data in Tables 2 to 7. It was obtained by adding the germ content of all the samples taken from the animal and then dividing the sum by the number of samples. The calculations were made for 1914 and 1915 separately. With but few exceptions, each average in 1914 represents fifteen to seventeen samples and in 1915 ten samples. In all, samples were taken from 89 different cows, 49 of which were milked during both years, so that 138 averages were obtained; these are shown in Table 9.

Of the 72 averages in Barn I, 30 were below 1,000 bacteria per cubic centimeter of milk, 35 were between 1,000 and 5,000, only 7 were over 5,000, and of these seven only 2 over 10,000. In Barn II, 30 of the 47 averages were below 1,000, and the highest average was only 3,599. In Barn III, all the averages were above 1,000 bacteria per cubic centimeter of milk, 11 were below 5,000, 6 were between 5,000 and 10,000, and 2 were over 10,000.

As in the germ content of the individual samples of milk, so also in the average germ content of the milk of the different animals, a considerable variation took place. For example, in Barn I Cow 174 had an average of only 183 bacteria per cubic centimeter, while Cow 55 had an average of 35,131. In Barn II, Cow 166 had an average of 149 bacteria, while Cow 550 averaged 3,599. In Barn III, Cows 1034 and 1026 averaged 1,971 and 19,093 bacteria, respectively. It is also

of interest to note that the averages of the cows that were milked during both 1914 and 1915 were different for each year. In some cases the difference was very marked; for example, the average germ content of the milk from Cow 167 was 444 bacteria per cubic centimeter for 1914 and 6,092 for 1915, and the milk from Cow 152 averaged 1,044 and 12,168 bacteria, respectively, for the two years.

TABLE 9.—AVERAGE GERM CONTENT OF MILK OF INDIVIDUAL COWS FOR 1914 AND 1915 RESPECTIVELY

Barn I

Cow No.	Average germ content per cc.		Cow No.	Average germ content per cc.		Cow No.	Average germ content per cc.	
	1914	1915		1914	1915		1914	1915
26	872	1479	155	613	408	187	585	1110
35	723	.....	156	763	962	188	5231	718
55	35131	26840	167	444	6092	189	387	1446
63	657	.....	171	602	2558	190	1140	4899
73	927	1656	172	3874	4895	191	2213	4571
74	931	986	174	183	1117	192	888	1476
110	665	1679	176	826	2878	193	.....	2955
111	6835	.....	177	758	4968	194	.....	2816
112	2010	2185	178	925	.....	195	.....	1998
130	751	8250	179	837	1088	196	.....	454
134	1164	845	180	2529	743	198	.....	1012
135	325	870	181	.....	2421	199	.....	3999
150	506	1019	182	833	.....	200	.....	1757
152	1044	12168	184	1391	.....	202	.....	3451
154	1307	.....	186	1042	.....	203	.....	1033

Barn II

Cow No.	Average germ content per cc.		Cow No.	Average germ content per cc.		Cow No.	Average germ content per cc.	
	1914	1915		1914	1915		1914	1915
108	770	.....	159	373	311	553	1045	.....
113	636	.....	164	813	948	554	1292	.....
116	265	308	165	356	.....	555	3588	.....
117	1217	189	166	295	149	556	1117	1374
118	2752	1766	170	222	633	557	603	.....
123	329	801	175	2425	.....	558	.....	266
125	689	.....	183	1613	1047	559	.....	555
131	1878	.....	501	.....	236	560	.....	1789
137	1369	.....	550	735	3599	561	.....	548
145	657	886	551	1258	396	562	.....	1387
149	966	901	552	635	212	...	.....	.....

Barn III

Cow No.	Average germ content per cc.		Cow No.	Average germ content per cc.		Cow No.	Average germ content per cc.	
	1914	1915		1914	1915		1914	1915
113	.....	6991	1018	5324	9342	1031	3150	4010
137	.....	2124	1019	2748	3759	1032	4603	5086
1003	13120	.....	1025	4320	.....	1033	4598	4834
1015	6414	9178	1026	19092	.....	1034	2667	1971

AVERAGE GERM CONTENT OF ALL THE MILK AT DIFFERENT MILKINGS

In order to get the average germ content of all the milk produced at each milking, it was necessary to calculate it from the individual records, since all samples were taken from the milk of individual cows and not from mixed milk of all the cows. This average germ content was obtained, therefore, by dividing the total number of bacteria in all the milk produced at one milking by the total number of cubic centimeters of that milk. The results of that calculation are tabulated in Tables 10 to 15.

TABLE 10.—GERM CONTENT OF TOTAL DAILY MILK PRODUCTION: BARN I, 1914

Date	Total milk production in cc.	Total germ content of milk	Average germ content per cc. of milk	Number of cows milked
March 10	143 023	755 465 800	5 282	26
" 12	70 588	127 812 050	1 810	15
" 13	89 312	142 995 080	1 601	16
" 16	111 596	182 759 800	1 637	19
" 17	205 919	517 618 914	2 513	38
" 19	199 449	484 142 870	2 427	36
May 13	111 816	106 981 000	956	20
" 21	118 673	216 010 400	1 820	21
" 22	121 002	875 150 800	7 232	21
" 27	126 189	190 681 800	1 511	21
" 29	129 177	63 204 120	489	21
June 1	118 145	109 030 430	838	20
" 2	118 848	48 210 540	405	20
" 3	117 530	79 945 420	680	20
" 5	54 765	39 311 100	710	10
" 8	99 377	1 043 284 410	10 498	19
" 9	70 368	186 545 700	2 650	15
" 10	56 567	96 776 750	1 710	12
" 11	104 430	82 884 940	793	19
" 12	104 652	208 767 710	1 994	20
" 13	96 532	63 049 660	653	19
" 15	84 196	42 916 160	509	17
" 16, a. m.	71 335	75 607 499	1 059	15
" 16, p. m.	58 237	172 980 510	2 970	15
" 17, a. m.	65 533	40 232 670	613	14
" 17, p. m.	50 897	52 797 540	1 037	13
" 18, a. m.	68 874	69 369 560	1 007	13
" 18, p. m.	55 512	84 315 960	1 519	14
" 19, a. m.	61 973	52 388 390	845	14
" 19, p. m.	25 492	16 615 430	651	8

TABLE 11.—GERM CONTENT OF TOTAL DAILY MILK PRODUCTION: BARN I, 1915

Date	Total milk production in cc.	Total germ content of milk	Aver. germ content per cc. of milk	Number of cows milked
March 10	209 760	703 593 000	3 354	33
" 11	238 450	697 614 000	2 925	37
" 12	228 920	709 389 000	3 105	36
" 13	228 700	722 367 000	3 158	36
" 15	233 200	856 499 000	3 673	35
" 16	243 760	885 118 000	3 630	35
" 17	232 350	892 646 000	3 840	34
" 18	245 750	719 825 000	2 928	35
" 20	237 000	736 142 000	3 105	35

TABLE 12.—GERM CONTENT OF TOTAL DAILY MILK PRODUCTION: BARN II, 1914

Date	Total milk production in cc.	Total germ content of milk	Aver. germ content per cc. of milk	Number of cows milked
March 23	166 099	146 887 500	884	26
" 25	172 647	96 287 000	557	25
" 26	195 197	202 127 100	1 035	25
" 27	168 340	125 835 100	747	23
" 30	195 943	435 882 000	2 224	23
April 2	201 217	347 905 800	1 720	23
" 3	200 426	45 504 300	227	23
" 6	203 634	95 930 600	401	23
" 8	203 283	55 541 600	272	23
" 9	166 099	63 860 400	384	23
" 15	201 745	204 035 300	1 011	23
" 18	202 228	189 717 900	938	23
" 22	211 326	225 902 200	1 068	23
" 24	206 976	212 762 400	1 027	22
" 27	200 558	371 639 600	1 853	21

TABLE 13.—GERM CONTENT OF TOTAL DAILY MILK PRODUCTION: BARN II, 1915

Date	Total milk production in cc.	Total germ content of milk	Aver. germ content per cc. of milk	Number of cows milked
March 30	171 250	183 603 000	1 072	21
" 31	174 680	103 339 000	591	21
April 1	170 420	74 382 000	436	21
" 2	169 360	340 440 000	2 010	20
" 5	167 670	107 045 000	638	21
" 6	170 720	130 837 000	766	21
" 7	172 660	127 417 000	737	21
" 8	172 140	116 521 000	676	21
" 9	172 480	151 763 000	879	21
" 12	172 780	87 308 000	505	21

TABLE 14.—GERM CONTENT OF TOTAL DAILY MILK PRODUCTION: BARN III, 1914

Date	Total milk production in cc.	Total germ content of milk	Aver. germ content per cc. of milk	Number of cows milked
April 15	73 929	384 652 800	5 203	10
" 18	72 566	385 029 700	5 305	10
" 28	54 502	502 218 700	9 214	10
" 30	50 854	200 743 700	3 947	10
May 1	60 523	252 388 900	4 180	10
" 2	50 106	340 778 300	6 801	10
" 4	57 974	382 213 700	6 592	10
" 5	53 271	238 415 500	4 475	10
" 6 a. m.	55 029	244 532 300	4 443	10
" 6 p. m.	48 041	317 808 600	6 615	10
" 11	50 326	361 966 200	7 192	9
" 12 a. m.	48 964	282 436 100	5 768	9
" 12 p. m.	38 811	589 285 700	15 183	9
" 13	50 634	199 918 900	3 948	9
" 14	50 898	432 363 200	8 612	9
" 16	48 480	200 273 700	4 131	9
" 18	48 172	336 195 700	6 979	7

TABLE 15.—GERM CONTENT OF TOTAL DAILY MILK PRODUCTION: BARN III, 1915

Date	Total milk production in cc.	Total germ content of milk	Aver. germ content per cc. of milk	Number of cows milked
March 23	49 884	291 376 000	5 842	9
" 24	55 298	287 836 000	5 202	8
" 26	59 025	225 417 000	3 819	8
" 27	62 855	312 854 000	4 977	8
" 29	55 525	258 690 000	4 659	8
April 1	49 713	498 719 000	10 031	8
" 2	47 780	129 098 000	2 702	8
" 5	49 010	162 435 000	3 314	7
" 7	54 110	308 700 000	5 705	8
" 21	33 625	135 038 000	4 541	5

An examination of Tables 10 to 15 shows that the variation in the number of bacteria in the milk at the different milkings was surprisingly small in each barn.

This is particularly true of the results from Barn I for 1915 and from Barn II for 1914 and 1915. The lowest average daily count in Barn I during 1915 was 2,224 and the highest count was 3,840 bacteria per cubic centimeter. In Barn II for 1914 the lowest count was 227 and the highest count was 2,224, and for 1915 the lowest count was 436 and the highest count was 2,010 bacteria per cubic centimeter.

A somewhat more pronounced variation in the average daily germ content was obtained from Barn I for 1914. During that year, however, the samples at that barn were taken from only a part of the herd and, furthermore, not from the same cows at each milking, and it is

probable that the greater variation was partly due to this procedure.

It is of interest to note that the few exceptionally high average daily counts, particularly the counts of May 22 and June 8, 1914, in Barn I, and those of May 12, 1914, and April 1, 1915, in Barn III, were due to exceptionally high counts in the milk of one or two cows. For example, in Barn I, on June 8, 1914, the total number of bacteria in the milk of the 19 cows from which the samples were taken was 1,043,284,410, of which number 958,814,000 were in the milk of Cow 55 and only 84,470,410 were in the milk of the remaining 18 cows. If this cow's milk had been excluded, the average germ content of the milk of the remaining 18 cows would have been about 1,000 bacteria per cubic centimeter; but with the milk of Cow 55 included, the germ content was 10,498 bacteria per cubic centimeter.

COMPARISON OF THE RESULTS FOR 1914 AND FOR 1915

As previously noted, in 1914 the udders of all the cows in the three barns were wiped with a damp cloth previous to each milking, but in 1915 this practice was discontinued. In all other respects, so far as possible, the same conditions and operations were maintained during both years. However, in a study of this nature certain factors which may affect the germ content of the milk are often beyond the control of the investigator. For example, in 1914 the study extended from March 10 to June 20, while in 1915 it was necessary to confine the study to March and April. According to Stocking, the different milkers may decidedly influence the germ content of the milk. In this study only two of the sixteen milkers employed in the three barns during the two years remained thruout the entire period of the experiment. Moreover, not all the cows milked in 1914 were milked in 1915. Some of those milked in 1914 were sold, and some new ones were added during the period between the experiments of 1914 and 1915. Thus 71 cows were milked in 1914 and 67 in 1915, and only 49 of these were milked during both years.

The difference between the data obtained in 1914 and in 1915 may be emphasized by a comparison based on the average counts of the different cows grouped as shown in Table 16.

It is seen from Table 16 that there was no appreciable difference in the grouping of the animals in Barn II and Barn III for the two respective years. On the other hand, in Barn I there were 22 cows in the first group and 10 in the second group in 1914 and only 8 cows in the first group and 25 cows in the second group in 1915. If the results are expressed in percentage, it will be found that in Barn I, 62.9 percent of the 35 cows milked in 1914 and only 21.6 percent of the 37 cows milked in 1915 were in the first group, while the second group contained only 28.6 percent of the cows in 1914 and 67.6 percent of the cows in 1915.

TABLE 16.—COMPARISON OF RESULTS IN 1914 AND 1915 BASED ON AVERAGE GERM CONTENT OF MILK OF THE INDIVIDUAL COWS

	Number of cows having average germ content of milk—		
	Below 1,000 per cc.	Between 1,000 and 5,000 per cc.	Over 5,000 per cc.
Barn I:			
1914	22	10	3
1915	8	25	4
Barn II:			
1914	15	11	0
1915	15	6	0
Barn III:			
1914	0	6	4
1915	0	5	4

When the data for each of the two years are compared on the basis of the average germ content, per cubic centimeter, of all the milk produced in each barn during the entire study, the relation shown in Table 17 is obtained.

TABLE 17.—COMPARISON OF RESULTS OF 1914 AND 1915 BASED ON THE AVERAGE GERM CONTENT OF MILK FOR THE THREE BARNS

	Average germ content per cc. of milk	
	1914	1915
Barn I	2 140	3 260
Barn II	973	830
Barn III	6 189	5 050
Average	2 188	2 552

Table 17 shows that the milk produced in Barn I had a germ content of 1,120 bacteria per cubic centimeter less in 1914 than in 1915, while the milk from Barn II had a germ content in 1914 of 143 bacteria more than in 1915, and the milk from Barn III had a germ content of 1,139 more in 1914 than in 1915.

The data for the two years may also be compared on the basis of the average germ content of all the milk produced in all three barns in 1914 and 1915, respectively. Such calculations show that the milk produced in 1914 during the course of the experiment had an average germ content of 2,188 bacteria per cubic centimeter and in 1915 an average germ content of 2,552 bacteria per cubic centimeter. In other words, every cubic centimeter of milk in 1914 contained 364 bacteria less than in 1915.

In all three barns the only operation that was intentionally altered during the two years was that of wiping the cow's udder with a damp cloth previous to each milking. The data for the two years show that in Barn I there was an appreciable increase and in Barn III an appre-

ciable decrease in the germ content of the milk in 1915, and in Barn II the germ content of the milk was approximately the same for both years. It is evident that no conclusion can be drawn from the data concerning the relative importance of the practice of wiping the udders as compared with the other sources of contamination in these barns. The data, however, do point to the conclusion that the wiping of the udders under the conditions obtaining in these barns did not affect the germ content of the milk to any appreciable extent.

It is also to be noted that altho pronounced fluctuations in the numbers of bacteria do occur in the individual samples and in the averages of the different cows, the collective influence of all the sources of contamination on the germ content of the total daily milk production was remarkably uniform for both years in each of the three barns.

NUMBER OF BACTERIA ADDED TO THE MILK BY ALL THE BARN FACTORS IN EACH OF THE THREE BARNS

The results obtained from the 1,665 samples of milk from the three barns show pronounced variation. Accordingly, any attempt to estimate the combined influence of the various sources of contamination in any barn on the basis of a single set or a small number of sets of analyses gives no dependable results. On the other hand, the massing of the results from a large number of samples should give figures which are fairly representative. The data are therefore brought together in Table 18 so as to show the total milk production in each barn during the study, the total number of bacteria in the milk, and the average germ content per cubic centimeter of milk.

TABLE 18.—GERM CONTENT OF THE TOTAL MILK PRODUCTION FROM EACH BARN

	Total milk production in cc.	Total germ content of milk	Average germ content per cc. of milk
Barn I:			
1914	2 909 880	6 227 838 000	2 140
1915	2 343 540	7 640 708 000	3 260
Total	5 253 420	13 868 546 000	2 639
Barn II:			
1914	2 895 718	2 819 813 000	973
1915	1 714 160	1 422 655 000	830
Total	4 609 878	4 242 468 000	920
Barn III:			
1914	913 080	5 651 213 000	6 189
1915	516 825	2 610 163 000	5 050
Total	1 429 905	8 261 376 000	5 777

According to these calculations, all the sources of contamination in these barns contributed, as an average for the entire investigation, 2,639 bacteria per cubic centimeter to the milk from Barn I, 920 bacteria to the milk from Barn II, and 5,777 bacteria to the milk from Barn III.

The purpose of this investigation was, as stated before, to measure the collective influence of all the barn factors upon the germ content of the milk, and not to measure their influences separately. Nevertheless, the data obtained point to certain conclusions concerning the relative importance of some of the separate factors.

The influence of the udder of a given cow is confined to her own milk, and when her udder is a large factor, numerically, her milk will have a large germ content regardless of the degree of cleanliness of the barn and the cow. An examination of Table 9, page 42, brings out the fact that the number of bacteria added to the milk by the udder was small in the case of most of the animals. In Barns I and II, 61 cows were milked in 1914 and 58 cows in 1915. The average germ content of 60 of these 119 cows milked during the two years was less than 1,000 bacteria per cubic centimeter, and of 32 cows the average germ content was between 1,000 and 2,000 bacteria. It is evident, therefore, that since the small average counts of these 92 cows were due to all the barn factors, their udders could not have been numerically a large factor. Of the remaining 27 cows, 20 had average counts between 2,000 and 5,000; 4 averaged between 5,000 and 10,000; one averaged 12,168; and one had an average of 35,131 for 1914 and 26,840 for 1915. In the case of the last animal, Cow 55, additional study showed that, altho apparently healthy, she persistently gave milk with a high germ content, the source of which was her udder.

The average germ content of the milk from Barn I for the entire investigation was 2,639 bacteria per cubic centimeter. If Cow 55 were omitted from the calculations, the average would be reduced approximately 1,000 bacteria per cubic centimeter. In other words, the udder of Cow 55 alone contributed about two-fifths of all the bacteria that were found in all the milk produced in Barn I during the entire investigation. These results point to the conclusion that in the production of milk of low germ content, the udder of some cows may become the principal source of contamination.

This conclusion is supported by the studies of Hastings and Hoffman and of Harding and Wilson. Hastings and Hoffman[1] concluded that "there is no reason to believe that the average bacterial count of milk as it is drawn from the udders of healthy cows is over 1,000 bacteria per cubic centimeter." These authors, however, found that the milk from two cows in the herd studied averaged 30,700 and 38,800 bacteria per cubic centimeter, respectively. In a more

[1]Hastings, E. G., and Hoffman, C. Bacterial Content of the Milk of Individual Animals. Wis. Agr. Exp. Sta. Res. Bul. 6, pp. 189-196. 1907.

extensive study, Harding and Wilson[1] examined 1,230 samples of milk taken directly from the udders of 78 cows. This examination showed that, on the average, only 428 bacteria per cubic centimeter were added to the milk by the udders of these cows, but that 8 percent of the samples contained more than 1,000 bacteria per cubic centimeter, and the highest count was 16,610.

The 2,639 bacteria per cubic centimeter in the milk from Barn I may be considered to have been derived from three separate sources; namely, the udder of Cow 55, the udders of the remaining cows, and the barn factors. Since none of the cows in Barn II gave uniformly high counts, the 920 bacteria per cubic centimeter of the milk from this barn may be considered as having been derived from two sources—the udders of the cows and the barn factors. If it is assumed that approximately 500 bacteria per cubic centimeter were added by the cow's udders, it will be seen that the conditions and operations at Barn I, omitting Cow 55 from consideration, contributed approximately 1,100 bacteria per cubic centimeter of milk, and at Barn II about 400.

The general appearances of Barns I and II would seem to indicate that Barn I was the cleaner; and yet from the above deductions it is seen that more bacteria were added to the milk at Barn I than at Barn II. It might be argued from the results obtained at these two barns that a dirty barn does not contribute more bacteria to the milk than a clean barn. Such conclusion, however, would be against a well established fact. This apparent discrepancy is only a side issue to the general problem, and it would be a mere conjecture to attempt to explain it. The real significance of the results from these two barns lies in the fact that the number of bacteria in the milk from both barns was remarkably small, and that the difference in the conditions and the operations in the two barns exerted practically negligible influence upon the germ content of the milk.

Even more significant are the results from Barn III. The average contamination here was 5,777 bacteria per cubic centimeter. This milk, so far as the germ content was concerned, would meet the requirements for certified milk, and yet the conditions of the barn as to cleanliness were such that it is doubtful whether the milk produced here would have been admitted to the milk supply of some cities.

These results must not be construed as a defense of dirty barns. They simply point to the fact that the large numbers of bacteria commonly found in milk do not have their origin in the barn.

[1]Harding, H. A., and Wilson, J. K. A Study of the Udder Flora of Cows. N. Y. (Geneva) Agr. Exp. Sta. Tech. Bul. 27. 1913.

SUMMARY

This study was conducted in three dairy barns, differing widely in the degree of cleanliness. Samples were taken from the milk of individual cows when the milk was brought from the barn to the milk room and the germ content of each sample was then determined.

A total of 1,665 samples were taken from 138 cows. The samples were collected during March, April, May, and June in 1914 and again during March and April in 1915.

While the germ content of the individual samples varied from 3 to 218,250 bacteria per cubic centimeter, the large majority of the samples in all three barns had a low germ content. The average germ content of the milk of individual cows was low in most cases. Cow 55 had the highest average of 35,131 bacteria per cubic centimeter of milk, but the udder of this animal was the source of this high average. The average germ content of all the milk produced at each milking was over 10,000 only once in Barn I and only twice in Barn III, and in Barn II the highest average was only 2,224.

The milk produced in 1914 and in 1915 had approximately the same germ content. The average germ content of all the milk produced during the entire study was 2,639 bacteria per cubic centimeter in Barn I, 920 in Barn II, and 5,777 in Barn III.

CONCLUSIONS

The study of these three barns shows that even under wide extremes in barn conditions it is possible to produce milk with a germ content of less than 10,000 bacteria per cubic centimeter when the utensils are properly prepared.

These intensive studies made at the Illinois and at the New York Agricultural Experiment Stations, together with accordant observations upon about twenty-five ordinary dairy barns by the former institution[1] and upon thirty-four dairy barns by the latter institution,[2] make it plain that when the influence of utensils is excluded, the dairy barns exert little measurable influence upon the germ content of the milk.

[1] In connection with other studies not included in this bulletin, samples of milk from about one hundred different barns have been recently examined for germ content, and in no case did the varied conditions in the barn have any marked effect upon the germ content of the milk.

[2] Brew, James D. Milk Quality as Determined by Present Dairy Score Card. N. Y. (Geneva) Agr. Exp. Sta. Bul. 398. 1915.

ACKNOWLEDGMENT

Whenever attempts are made to measure barn activities, the attitude of the workmen becomes an important element in the success of the study. Because such measurements add something to their labor, the men may become antagonistic; or because such measurements may be taken as an index of the care with which they do their work, they may modify their actions during such tests so as to lead to abnormal results. Either of these attitudes may modify the results and endanger the conclusions. Accordingly, the colleague who has immediate charge of the barn workmen becomes a vital part of the investigation and his influence in keeping barn conditions normal during the progress of the study is a large factor in the success of the work.

Both because of the harmonious relations which have existed and on account of numerous check experiments, we believe that the results here given are representative of the conditions regularly obtaining in the three barns in which this investigation was made. These barns were under the supervision of Professor W. J. Fraser, and Messrs. R. S. Hulce and W. T. Crandall. The authors are greatly indebted to these colleagues for their hearty cooperation, without which the investigation could not have been performed successfully.